**Innovative capacity building strategy in the fuel and energy complex**

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**Abstract.** This article analyzes current aspects of the development of innovative potential in the fuel and energy complex, existing problems, and strategies for their elimination. The importance of scientific and technical achievements and modern technologies in ensuring the sustainable development of the energy sector is substantiated. Ways to increase the competitiveness of the industry by stimulating innovation, improving the investment climate, and increasing human resources potential were considered. National strategic approaches based on advanced foreign experience have also been proposed.

**INTRODUCTION**

Today, the strategic goal of the policy for developing internal energy markets in the world is to ensure stable satisfaction of the domestic demand for high-quality fuel-energy resources needed for sustainable economic growth, as well as to maximize the efficient use of natural fuel-energy resources and the capacities of the energy sector. The issue of managing, saving, and efficiently using fuel-energy resource consumption has become one of the priority areas in the development of oil and gas extraction enterprises and companies operating in the production sector through the application of innovations.

In recent years, the growing importance of the concept of sustainable development worldwide, the popularization of its ideas and fundamental principles, and the increasing urgency of conducting deeper research on the management of fuel-energy resource consumption in the global economy demonstrate the relevance of this field. It is clear that this area requires the application of multidisciplinary scientific knowledge; therefore, multifaceted research needs to be conducted. In market relations, making uncertain decisions at any level of the management system of oil and gas extraction enterprises may lead to severe negative consequences. Hence, the use of information and communication technologies is essential to reduce the time spent on implementing production and economic operations and to ensure reliable decision-making (Ishanxodjayeva, 2021).

The problems of developing oil-gas enterprises in the economy, including the active introduction of innovative technologies into extraction, drilling, and processing operations, are sufficiently covered in scientific studies. However, due to the specific nature of the national economy—particularly the fuel-energy industry—and its critical role within the economy, research on the effective organization of investment processes, taking into account the open interests of all parties involved, as well as the development of economic models and mechanisms for this process, has yet to be adequately addressed (Umurzoqov, 2024).

Introducing new equipment and technologies is a highly complex and contradictory process. It is traditionally believed that improving technical tools reduces labor costs and the share of labor in the cost of production. However, technological progress has become increasingly costly, as it requires creating and operating more expensive machinery, lines, robots, and computer-based control tools and leads to increased expenditures on environmental protection. All of these factors are reflected in the increased share of depreciation and technical expenses of fixed assets in production costs. Nevertheless, the competitiveness of a firm or enterprise—their ability to remain in the goods and services market—depends on their capacity to produce and sell high-quality products by efficiently using material resources and introducing innovations.

**RESEARCH METHODOLOGY**

This research applies a systemic approach aimed at thoroughly analyzing the challenges of enhancing the innovation potential of the fuel-energy complex, assessing the current state, and developing effective strategic solutions. The study integrates theoretical, empirical, and statistical methods within a comprehensive analytical framework.

**LITERATURE REVIEW**

Taraxtiyeva (2015) notes that the oil-gas complex is a technologically complex production system. It consists of economic entities that provide exploration of oil and gas and their processed products, well construction, extraction, transportation, processing, and sales. Increasing oil extraction today is associated with developing small fields and reserves that are difficult to extract, which, in turn, requires substantial resources for applying, installing, and operating innovations.

Shortanov (2022) argues that cooperation in the sector is driven by numerous factors, including the need to meet the growing needs of various countries' populations. One of the most important areas of international cooperation, according to him, is innovation capacity in the fuel-energy sector.

Raximov (2022) highlights that the issue of disposing of oil-gas industry waste unites two major concerns: protecting the environment from pollution and conserving resources. Waste, on the one hand, creates a heavy burden on life on Earth; on the other hand, if managed using innovative methods, it can serve as a significant source of wealth.

Maxmudov (2024) states that implementing a modern billing information-communication system—from energy production to delivery to consumers—can increase resource efficiency through automated metering and monitoring of electricity and natural gas consumption.

Ishanxodjayev (2021) proposes improving the models and algorithms in each stage of fuel-energy resource savings management—“standardization-planning-operational recording-systematic analysis-decision-making”—based on systematic analysis.

Vahobov (2021) asserts that the importance of the oil and gas industry plays a key role in ensuring the economic independence of any country. Since the raw-material base of the oil and gas industry—oil, gas, hydrocarbons, coal—consistently brings higher revenues than other sectors and remains in high global demand, implementing innovative management systems strengthens enterprise capabilities.

Sultanov (2018) identifies solving the issues of managing fuel-energy resource consumption and increasing efficiency as some of the priority tasks for the development of oil-gas extraction enterprises and the introduction of innovations. He emphasizes that systematic management is one of the crucial aspects of successful enterprise operations.

Saidova (2023) notes that the basis of energy saving is the rational use of energy resources and reducing their losses. She emphasizes the need for legal, organizational, financial, and economic regulation of national energy-saving policies, widely implemented in developed countries.

**ANALYSIS AND RESULTS**

Considering the specific features of oil production, innovation is an interconnected set of stages covering the entire technological chain—from the emergence of an idea, commercialization, and practical application to replacing it with an improved, more advanced version. Revitalizing the activity of the oil sector depends heavily on increasing investment levels, which currently remain insufficient for innovative development. The specific characteristics of the oil and gas industry require substantial investment into innovative projects and technologies. Key barriers to innovation include:

-Funding limitations: over the past five years, R&D funding has accounted for only 3 percent of the total investment in the industrial sector.

-Regulatory restrictions: certification and standardization systems are outdated, slowing the implementation of technological innovations.

-Workforce shortages: only a small share of specialists in the energy sector are skilled in modern technologies and innovation, leading to deficiencies in human capital.

Globalization and technological transformation position the fuel-energy complex (FEC) as one of the main drivers of economic growth and social welfare. According to the International Energy Agency, global energy consumption increased by 2.3 percent in 2024, driven primarily by the deployment of innovative technologies (IEA, 2024).

Uzbekistan is actively participating in these global processes. Direct foreign investment in the energy sector has increased 1.8 times in 2024 compared to 2018. In 2024, investments in renewable energy reached 1.2 billion USD.

However,only 2 percent of total energy investments in Uzbekistan are allocated to R&D, compared to 7–10 percent in developed economies.As geological and extraction conditions become more complex, modern technologies are increasingly needed: geological-hydrodynamic 3D modelling, virtual-reality-based modeling, advanced drilling and reservoir-enhancement technologies, innovative oil collection, transportation, and preparation methods.

**Table 1.** Key Challenges and Proposed Strategic Solutions for Innovation in Uzbekistan’s Fuel and Energy Complex

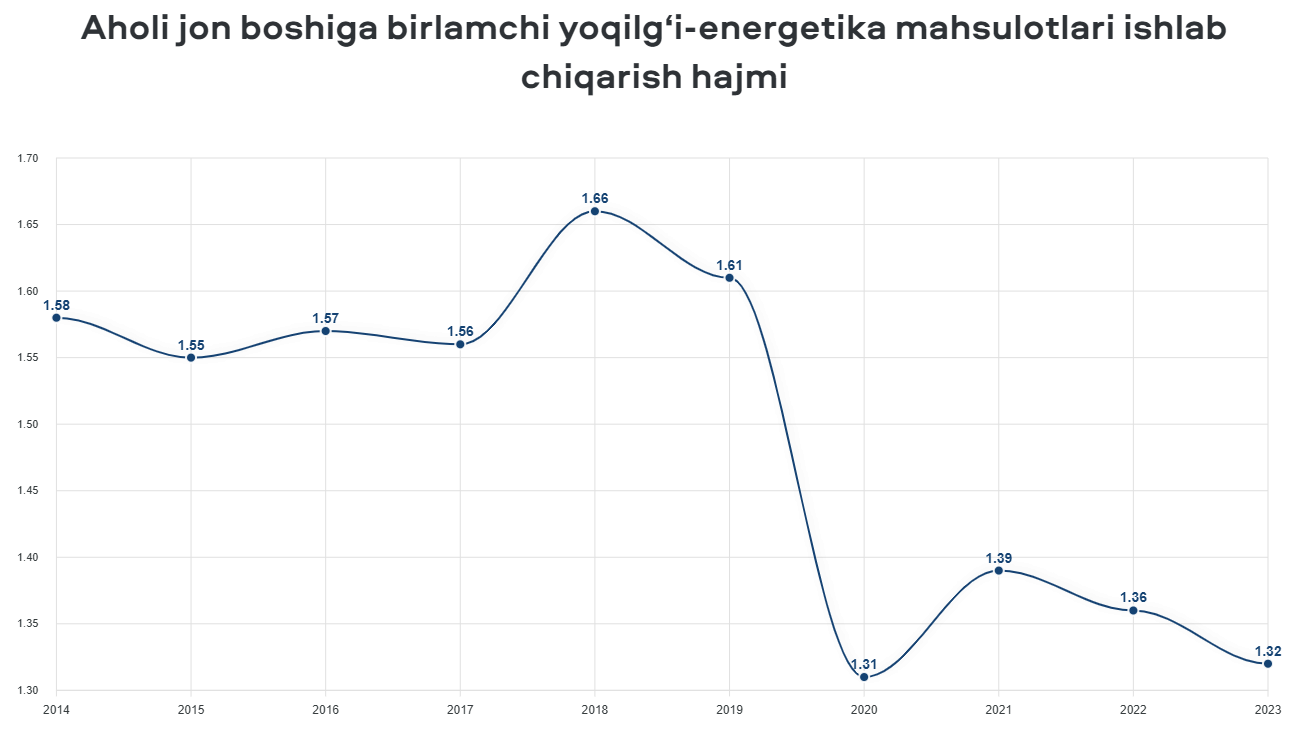
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| **Problem** | **Possible solution** | **What needs to be done** |
| Lack of clear legal protection for intellectual property created between business and the state | Strengthen and agree on procedures for using intellectual property at the pre-project stage | Define legal criteria allowing R&D expenses not directly tied to current income to be included in deductible profit-tax expenses; revise the R&D ex |
| Absence of pilot facilities for testing and developing new technologies | Create infrastructure-technology clusters for test equipment | Establish technoparks and business incubators based on research institutes and leading universities; develop sectoral clusters. |
| Complex rules for using state budget funds; inability to attract loans (for budget institutions) | Remove restrictions on fund allocation among project executors | Create consortia and management companies that finance high-risk innovation projects. |

Source: Tarakhtiyeva Gulmira Kulbaevna (2015). Innovations and Their Role in Managing the Development of Uzbekistan’s Fuel and Energy Complex //Economics and Finance (Uzbekistan). No. 6.

Uzbekistan possesses substantial natural gas reserves. “Uzbekneftgaz” JSC operates 118 fields, producing natural gas in 85 of them, while exploration continues in the remaining 33. Its production share is: 63% of natural gas, 67% of gas condensate, 13% of oil.

Due to prolonged extraction, reservoir pressure in many fields has declined. To ensure production stability and maximize reserve recovery, additional compressor stations are required annually. Currently, 96 percent of natural gas production relies on compressor stations. In 2022, 84 drilling operations, 711 major well repairs, and 27 technological interventions were carried out.According to the World Bank, by 2030 nearly 60 percent of energy investments worldwide will be directed to innovative technologies and green energy. This indicates that industries dependent on traditional energy must accelerate innovation to remain competitive.In Uzbekistan, this challenge is even more pressing:

In 2024, electricity production reached 79 billion kWh, but only 7.5 percent came from renewables.This is significantly lower than the global average of 30 percent.



**Figure 1.** Primary Fuel-Energy Production per Capita (Tonnes of Oil Equivalent)

The data show that while the population is growing, per-capita production of fuel-energy resources is declining. This underscores the urgent need to develop innovative solutions in the sector. If we pay attention to the data in Figure 1, we can see that while the population of our country continues to grow, the per capita production volume of fuel and energy products is decreasing. This further demonstrates the importance of developing innovative solutions in this sector.

Enhancing innovation capacity in the fuel-energy complex is gaining strategic importance in line with global energy trends. According to the results for 2024, 86 percent of newly installed electricity generation capacity worldwide came from renewable energy sources (IRENA, 2024). According to data from the International Energy Agency (IEA), over the past three years, 55 percent of total investments in the energy sector have been directed toward the development of innovative technologies.

In our country, the share of renewable energy sources in total electricity generation has reached 9.2 percent. The total capacity of wind and solar power plants has exceeded 1.5 GW, and it is planned to increase this figure to 5 GW by 2026.

At the same time, electricity losses in energy networks amounted to 17.8 percent in 2023. The target is to reduce this indicator to 10 percent by 2030. In terms of financing, the volume of foreign direct investments in the energy sector in 2024 reached 2.3 billion USD, which is 18 percent higher than in 2022.

The level of digitalization in the energy sector is also increasing. As of early 2024, 28 percent of electricity supply was monitored through digital management systems. By 2025, this figure is expected to reach 50 percent.

The share of expenditures allocated to research and development (R&D) aimed at enhancing innovation capacity amounted to 3.5 percent as of 2024. The goal is to increase this indicator to 7 percent by 2030.

Expected outcomes include increasing energy production efficiency by 20 percent, raising the share of renewable energy to 25 percent by 2030, and expanding energy exports by 1.8 times.

The creation of clusters between energy enterprises and research institutes can accelerate the development of innovative products. For example, in Germany, R&D effectiveness increased by 1.5 times through the introduction of energy clusters. By implementing AI-based energy management systems, smart grids, and energy-efficiency technologies, Uzbekistan may reduce electricity losses to 12–15 percent.

Experience from developing countries indicates that the expansion of new high-tech industries serves as a key driver for overall economic development. This enables broader utilization of the economy’s existing advantages, reduces production and transaction costs, and ensures that newly developed products are aligned with market demand. In addition, localization-based investment projects support the efficient introduction of foreign partners’ technologies and expertise. Therefore, it is necessary to actively support the localization of new technologies through national mechanisms and instruments.

The innovative potential of fuel-energy resource utilization is influenced by a number of factors, including the normative consumption of resources, the variation in equipment, machinery, and technological line workloads throughout the year, and seasonal factors. Workload reductions may also result from unstable plant operations or declining demand for produced goods. Therefore, calculating the normative consumption of fuel-energy resources requires accounting for these influencing factors. Today, analytical-computational, experimental, and statistical-computational methods exist for standardizing fuel-energy resource consumption. A unified information database for managing fuel-energy saving processes enables accurate, up-to-date, and reliable data storage, fast execution of operations, and prevention of duplicate data. The primary goals of establishing such a unified database include:

-supporting industrial, economic, and financial decision-making in managing fuel-energy saving through an automated database;

-ensuring rapid access to accurate and relevant information for effective planning and control of production, economic, and financial processes in fuel-energy saving management;

-creating a normative information environment for standardization, certification, and provision of high-quality products.

Developing this unified database using an oil and gas extraction enterprise as an example enhances planning efficiency in fuel-energy resources, raw materials, component parts, financial resources, investments, and the operational and capital repair of wells, equipment, and technological lines. This also reduces the time and financial costs needed to prepare reliable data for rapid and effective management and monitoring (Sultanov, 2018).

Moreover, localization of foreign companies’ production and industrial services in our country not only helps substitute imports but also significantly optimizes existing production processes, creates new job opportunities through new production facilities, and ensures the generation of all mandatory payments and revenues.

**CONCLUSION**

In conclusion, the following can be stated:

-Establishing corporate innovation laboratories within energy enterprises will help further optimize their operations.

-Creating energy-innovation funds and actively involving the private sector will stabilize enterprises financially and expand opportunities for the implementation of innovations.

-Supporting new startup projects will facilitate the introduction of high-risk but high-return technologies into the energy sector. According to U.S. experience, more than 200 new technologies enter the energy sector annually through such startups.

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